CLAIMS

1. A method of measuring the QT interval of an electrocardiogram (ECG) signal wherein the end of the T wave is identified from ECG data, the end of the T wave being determined by reference to the timing of at least one intersection at which an upright T wave of a first set of derived ECG signal data intersects an inverted T wave of a second set of derived ECG signal data, the two sets of ECG data being superimposed so as to maximise their fit over a segment of the ECG signal after the positive T wave peak.

2. A method as claimed in claim 1 wherein the fit of said data is maximised by a least squares calculation.

3. A method as claimed in claim 1 or 2 wherein the method comprises the steps of:

(a) acquiring ECG signal data;

(b) deriving a first set of reduced noise ECG signal data from the acquired ECG signal data;

(c) inverting the first reduced noise set of ECG signal data to derive an inverted set of reduced noise ECG signal data;

(d) identifying a portion of each set of ECG signal data corresponding to a segment after the T wave;

(e) calculating an offset such as to fit the first set of data to the inverted set of data over said segment;

(f) detecting at least one intersection between the first and inverted set of data by reference to said offset; and

(g) determining the end of said QT intervals by reference to the timing of the detected intersection(s).

4. A method as claimed in claims 3 wherein in step (g) the end of the QT interval is determined by the first point intersection.

5. A method as claimed in any previous claim wherein the end of the T wave is defined at the first point of intersection in said segment, provided there is at least one other point of intersection after a predetermined interval.

6. A method as claimed in any previous claim wherein said interval can be varied according to the noise content in the segment of the ECG deemed to be the isoelectric line.

7. A method as claimed in any of claims 3 to 6 wherein the step (b) comprises calculating the median signal for each time from an ensemble of ECG signals for each lead to reduce low frequency baseline noise.

8. A method as claimed in any of claims 3 to 7 wherein the method (b) further comprises smoothing the median ensembled ECG signal with moving median filter to reduce high frequency noise.

9. A method as claimed in any of claims 3 to 8 wherein the method (b) further comprises filtering the median smoothed, median ensembled ECG using a wavelet frequency thresholding technique which substracts the magnitudes of any non-zero frequency components within the isoelectric baseline segement from the rest of the ECG thus further de-noising it.

10. A method as claimed in any of claims 3 to 9 wherein the step (b) further includes vertically shifting the smoothed median ensembled ECG signal so that the minimum value after peak of T is zero.

11. A method as claimed in any of claims 3 to 10 wherein the step (b) further comprises the steps of detecting and correcting baseline drift in the first set of ECG data.

12. A method as claimed in any preceding claim wherein the detecting step includes the testing for the presence of a single crossing of one isoelectric line.

13. A method as claimed in any preceding claim wherein the ensembled ECG can be rotated about a zero point or otherwise transformed to reconfigure the set of ECG data to have multiple crossings of said line.

14. A method as claimed in any of claims 3 to 13 wherein the step (b) further includes applying a non-linear function such as squaring the amplitudes of the signal for all time instants, in order to accentuate features of interest and ensure positive deflections of the T wave.

15. A method as claimed in any of claims 3 to 14 wherein the step (b) further includes summing the squared amplitudes of ensembled orthogonal leads over all time instants to give a squared resultant vector ensembled ECG.

16. A method as claimed in any preceding claim wherein the method further includes finding the beginning of the QT interval by an established method, for example from the median of ensembled ECG signals from all 12 leads.

17. A method as claimed in any preceding claim wherein the method includes calculating the QT interval by subtracting the beginning of QT from the calculated end of the T wave.

18. A method as claimed in any preceding claim wherein the QT interval is measured for the squared vector resultant data derived from quasi-orthogonal or actual orthogonal XYZ leads, and the longest of QT measurements made in 3 dimensions is made.

19. A method as claimed in any preceding claim wherein the ECG signal data may be acquired in step (a) from the set of standard ECG leads including I, aVf and V2.

20. An apparatus for measuring the QT interval of an electrocardiogram (ECG) signal wherein there is provided means for identifying the end of the T wave from ECG

data, the end of the T wave defined as the first time of intersection at which an upright T wave of a first set of derived ECG signal data intersects an inverted T wave of a second set of derived ECG signal data, the two sets of data being superimposed so as to maximise their fit over a segment of the ECG signal after the positive T wave peak.

21. An apparatus as claimed in claim 20 wherein the fit of said data is maximised by a least squares calculation.

22. An apparatus as claimed in claim 20 or 21 wherein the apparatus comprises:

means for acquiring ECG signal data;
means for deriving a first set of reduced noise ECG signal data from the acquired ECG signal data;
means for inverting the first reduced noise set of ECG signal data to derive an inverted set of reduced noise ECG signal data;
means for identifying a portion of each set of ECG signal data corresponding to a segment after the T wave;
means for calculating an offset such as to fit the first set of data to the inverted set of data over said segment;
means for detecting at least one intersection between the first and inverted set of data by reference to said offset; and
means for determining the end of said QT intervals by reference to the timing of the detected intersection(s).

23. An apparatus as claimed in claim 22 wherein in the means for determining the end of said QT interval, the QT interval is determined by the first point of intersection.

24. An apparatus as claimed in claims 22 or 23 wherein the end of the T wave is defined at the first point of intersection in said segment, provided there is at least one other point of intersection after a predetermined interval.

25. An apparatus as claimed in any of claims 22 to 24 wherein said interval can be varied according to the noise content in the segment of the ECG deemed to be the isoelectric line.

26. An apparatus as claimed in any of claims 22 to 24 wherein means for deriving a first set of reduced noise ECG signal data comprises means for calculating the median signal for each time from an ensemble of ECG signals for each lead to reduce low frequency baseline noise.

27. An apparatus as claimed in any of claims 22 to 26 wherein the means for deriving a first set of reduced noise ECG signal data further comprises means for smoothing the median ensembled ECG signal with moving median filter to reduce high frequency noise.

28. An apparatus as claimed in any of claims 22 to 27 wherein the means for deriving a first set of reduced noise ECG signal data further comprises means for filtering the median smoothed, median ensembled ECG using a wavelet frequency thresholding technique which substracts the magnitudes of any non-zero frequency components within the isoelectric baseline segement from the rest of the ECG thus further de-noising it.

29. An apparatus as claimed in any of claims 22 to 28 wherein the means for deriving a first set of reduced noise ECG signal data further includes means for vertically shifting the smoothed median ensembled ECG signal so that the minimum value after peak of T is zero.

30. An apparatus as claimed in any of claims 22 to 29 wherein the means for deriving a first set of reduced noise ECG signal data further comprises means for detecting and correcting baseline drift in the first set of ECG data.

31. An apparatus as claimed in any of claims 20 to 30 wherein detection includes means for the testing for the presence of a single crossing of one isoelectric line.

32. An apparatus as claimed in any of claims 20 to 31 wherein there is provide means for rotating the ensembled ECG about a zero point or otherwise transformed to reconfigure the set of ECG data to have multiple crossings of said line.

33. An apparatus as claimed in any of claims 22 to 32 wherein the means for deriving a first set of reduced noise ECG signal data further includes means for applying a non-linear function such as squaring the amplitudes of the signal for all time instants, in order to accentuate features of interest and ensure positive deflections of the T wave.

34. An apparatus as claimed in any of claims 22 to 33 wherein the means for deriving a first set of reduced noise ECG signal data further includes means for summing the squared amplitudes of ensembled orthogonal leads over all time instants to give a squared resultant vector ensembled ECG.

35. An apparatus as claimed in any of claims 20 to 34 wherein the apparatus further includes means for finding the beginning of the QT interval by an established method, for example from the median of ensembled ECG signals from all 12 leads.

36. An apparatus as claimed in any of claims 20 to 35 wherein the apparatus includes means for calculating the QT interval by subtracting the beginning of QT from the calculated end of the T wave.

37. An apparatus as claimed in any of claims 20 to 36 wherein the QT interval is measured for the squared vector resultant data derived from quasi-orthogonal or actual orthogonal XYZ leads, and the longest of QT measurements made in 3 dimensions is made.

38. An apparatus as claimed in any of claims 20 to 35 wherein the ECG signal data is acquired from the set of standard ECG leads including I, aVf and V2.

39. A record carrier wherein are recorded program instructions for causing a programmable processor to perform the steps of the method as claimed in claims 1 to 19, or to implement an apparatus having the features claimed in any of claims 20 to 38.